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Effects-Based Operations at the Operational Level of War: Exploring the Living System
Alternative

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Maritime Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature: _____

23 April 2008

Abstract

The concept of Effects-Based Operations (Effects-Based Approach to Operations) proves effective in a well-defined tactical environment, but less capable in the dynamic open environment at the operational level of war. Exploring the well-established relationship between control systems and EBO reveals fundamental problems with this concept in the areas of situation assessment, feedback, and prediction. The living system model provides an alternate construct for the environment found at the operational level of war. This model better represents the complex, open system found and is better able to overcome the disturbances that occur in open systems. With robustly designed systems and sub-systems, the ability to synchronize C2 at the organism and sub-system levels, and the acceptance of limitations in areas such as situation assessment and feedback, the living system model provides a better construct for defeating adversaries of all abilities.

Introduction

No single characteristic defines the allure of modern U.S. warfare better than the use of precision guided munitions (PGM) and targeted application of force to achieve dramatic effects with relatively little expenditure. The supposed validity of this premise has led the U.S. and many other nations down the path of Effects-Based Operations (and Effects-Based Approach to Operations) whereby understanding casual relationships, effects can be driven towards a desired end-state. As Clausewitz stated, however, in war “there is a gap between principles and actual that cannot always be bridged by a succession of logical deductions.”¹

With the advance of technology, the attempt to bridge this gap has been redoubled as the ability to model casual relationships would preclude much of the messiness of war. The model many subscribed to do this is Effects-Based Operations (EBO); a concept strongly related to control theory, which itself governs much of the technology employed by the U.S. As war is a struggle between living entities, however, any application of mechanistic theories to it makes assumptions that fail to fully account for the living nature of the system and force the question, “Is there a better model?” Darwin’s description of evolution as a “great and complex battle of life” and the constant “war” the organism fightS against external and internal forces perhaps reveals this better construct for war, the living system.²

Despite these overarching questions concerning the EBO construct, the tactical successes of EBO cannot be diminished. The ability to more completely consider the implications of actions on a well-defined battlefield during a finite timeframe, while not perfect, does present a better manner in which to conduct operations. It is at this tactical level that EBO was both first employed and where to date it has seen its greatest successes. With its longer event horizon, however, the operational level of war presents EBO with a more loosely-defined problem. Despite nearly universal admission of the complexity and

challenges of employing EBO at this level, proponents advocate that the issues here can be overcome by better technology, better intelligence, and better analysis. These solutions attempt to better utilize EBO by correcting deficiencies in the control system concept without questioning the validity of the concept itself. Even with these technical improvements, however, the application of EBO at the operational level of war does not overcome errors in the concept itself in the areas of system state, feedback, and prediction of disturbances leading to failures in the overall EBO model. In this model, despite the open nature of the system at the operational level of war, EBO is based upon the ability to accurately assess, re-assess, and predict the system state; an impossibility with the complex and dynamic nature of social systems at this level. Specifically, this assessment as well as prediction of disturbances and the manner in which they will affect the environment is facilitated by timely, complete, and accurate feedback; a requirement which is nearly unattainable at the operational level of war.

This paper will briefly examine the history of EBO, highlighting its tactical heritage and the strong relationship to control theory it bears. The assumptions implicit in control theory will then be explored as will the impact of these at various levels of war. The value of EBO will be looked at as well as the specific assumptions found in EBO. Living systems will then be presented as an alternate model for the operational level of war. The living system will then be shown to be more representative of the operational level of war than control theory. Finally, the specific aspects of living systems and the manner in which they can help to ensure better success at the operational level of war will be postulated.

History of Effects Based Operations

The desire to achieve specific effects through judicious application of force has always existed, but it began to coalesce into its modern form prior to World War II (WWII).

Advocates such as Douhet, Trenchard, and Mitchell pursued the idea of strategic bombing and its ability to achieved strategic effects when properly used.³ With the technology available in WWII, this proved to be an unrealized aspiration. Following WWII and lasting until Operation Desert Storm (ODS), however, ideas such as nodal analysis and measures of effectiveness continued to be refined by air planners in their pursuit of greater targeting efficiency. During this period, the tenets of EBO continued to grow primarily within the targeting world as U.S. Air Force advocates tried to accomplish missions with more efficient application of airpower. Once PGMs answered the question of “can we hit and damage what we are aiming for,” EBO finally went mainstream and moved from the targeting world to the operational world.⁴ The move from the targeting world to the mainstream military also meant moving beyond the tactical engagement, even those with strategic implications, to a broader concept that covers all levels of war. Moving to the higher levels of war exposed new problems with EBO as planners tried to move beyond the linear causality of tactical level engagements towards the complex relationships found at the operational and strategic levels of war. Despite the enormous challenges in this, advocates have pointed towards the rapid pace of technological growth as the panacea for these problems.⁵

With this historical context in mind, it is important to briefly explore some of the campaigns conducted using EBO and the issues raised by them. While WWII gave birth to the search for the “strategic bottleneck,” it always seemed a bridge too far as both friction in the form of faulty intelligence, incorrect casual linkages, and unexpected enemy responses as well as operational considerations including current weapons prevented successful employment.⁶ With the advent of PGMs, technology allowed planners to employ EBO in various forms and degrees in ODS, Operation Allied Force (OAF), Operation Enduring

Freedom (OEF), and Operation Iraqi Freedom (OIF). Despite the success found in each conflict in terms of precision strike and tactical engagements, the ability to correlate actions to effects and predict enemy activity still proved difficult.⁷ In OIF, despite the technological advances and a better defined operating concept, accurately assessing the initial conditions and using feedback to determine shifts in the operating environment proved unsuccessful as many of the predicted effects never materialized. Even in OAF, where the destruction of certain targets seemed to directly correlate with the enemy's capitulation, the success of EBO was repudiated by statements that Milosevic merely decided to capitulate and that local commanders viewed their objective as complete.⁸ Thus, 60 years after WWII, one still finds that in hindsight it is hard to know whether EBO led to success or merely achieved it by coincidental causality.

Control Theory

With EBO's lack of documented success, it is important to look at its fundamental underpinnings. As stated and recognized by many advocates, the structure of EBO is essentially the same as that of a control system.⁹ This fundamental relationship is more completely developed in several works published by the Command and Control Research Program (CCRP) with a more exacting study completed by Philip Farrell at the Defence R&D of Canada.¹⁰ Farrell breaks down the structure of EBO and relates the traditional EBO cycle to a control system in the following manner:

Current Situation (Initial State)	S _I	Knowledge
Desired Situation	D _S	Effects
Execution	E	Application
Assessment (Feedback)	A	Assessment
Planning	P	Adaptation

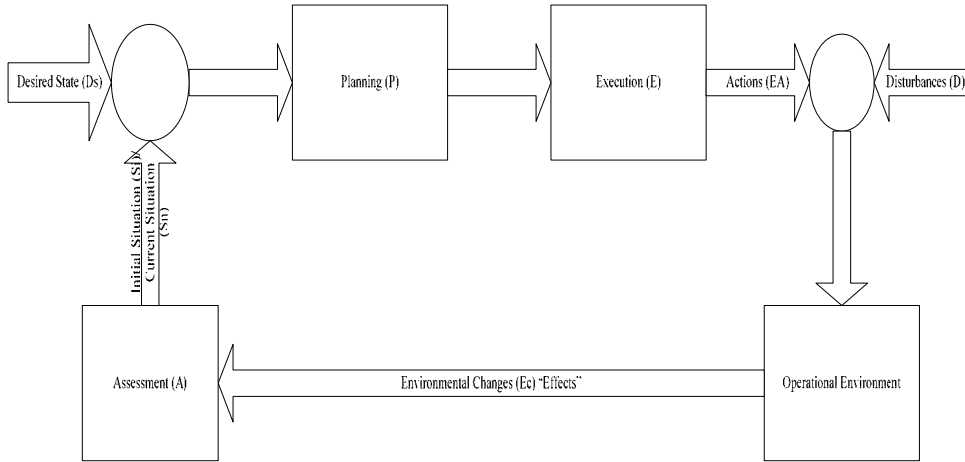


Figure 1: EBO Feedback Model (Adapted from Farrell)

Farrell's model is adapted in Figure 1 in several ways to better represent the EBO cycle.¹¹

First, several of the variables are renamed to better correlate with the EBO cycle. Second, the results of the actions and disturbances in the operational environment were designated as Environmental Changes (E_c) or "Effects." Finally, assessment leads to both determination of the Initial Situation (S_i) and the Current Situation (S_n) where n denotes the number of iterations this cycle has been through. This cycle represents the ideal where assessment leads to perfect knowledge of the initial situation, known environmental changes are representative of all environmental changes, and the disturbances (D) can be predicted or solved for much like a simple algebraic equation.¹² With the correlation between the control systems and EBO previously established, this work will focus on EBO's relationship with E_c , S_i/S_n , and the ability to determine or predict D .

Knowledge of the initial state is required in any control system to allow appropriate planning so that the desired state can be achieved in the operational environment. In non-living systems, this initial state is drawn from a total understanding of the environment such that when the cycle is put into action it starts from a given or known reference point. EBO is based on this same premise, meaning it is based on complete knowledge of the initial

situation and each subsequent assessment of the operational environment. Complete knowledge of the situation is one of the factors that drives the current EBO model, as the belief is that with greater knowledge the pitfalls of prior operations can be overcome.¹³

Feedback is derived from an assessment of the operational environment and the impact that the execution phase has on it. This requires an active feedback loop (E_c) that allows the assessors to evaluate the changes that have occurred from S_I . Comparing this feedback to the initial state determines whether or not the desired end state or an effect leading to it has been reached. In order to correctly make this assessment, however, the feedback must be timely, complete, and understood. Failure to achieve each of these will lead to the state changing before a new initial state can be known and corrections made, thus assuring the plans made will not correctly account for the current situation.

The application of control theory is different at each level of war primarily due to the manner in which it accounts for *disturbances*. Before addressing this, it is important to briefly explore disturbances as they apply to all levels of war. Disturbances are external actions that are not controlled by the initiators that interact with E_A to create the new operational environment that is assessed. To put it simply, this represents not only the friction found on the battlefield, but the friction added by every element of the environment. The ability to minimize or accurately predict the value of D at certain levels of war is a crucial factor in the viability of EBO. In this, accomplishing the minimization of D takes on very different forms at the different levels of war.

As stated earlier, at the tactical level of war, the EBO process has proven useful by conditioning planners to more completely assess the situation and the expected impact of their actions. This has been successful due mainly to the ability to create a pseudo-closed

loop system (Figure 2). Creating this at the tactical level is possible due to the short-term nature of operations, as well as the ability to effectively isolate the tactical battlefield environment in both time and space. This makes developing a useable feedback cycle easier and determining both S_I/S_N possible. Isolating the environment in this manner also allows either D to be minimized or, if this is not possible, the solving for D due to nearly complete knowledge of the environment.

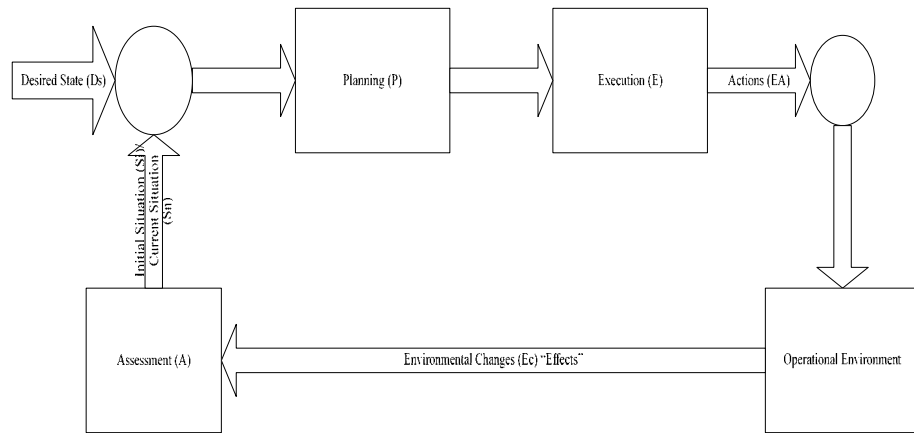


Figure 2: Tactical Level "Closed-Loop" EBO System.

Unlike at the tactical level, factor time and space at the operational level of war prevent modeling it as a closed system. With the inability to isolate space and time, the problem is greatly complicated by the need to account for D . This leads to challenges in determining not only D , but also in ascertaining the S_I/S_n and in attaining sufficient feedback.

Initial State – While near-complete knowledge of S_I is required, it is impossible with a large, complex, and open system to achieve this depth of knowledge. In addition to being near-complete, knowledge must also be timely.¹⁴ In dynamic situations such as those found in social systems, a snapshot of any moment is often wrong as soon as it is taken. Because of this, the process will always be incorrect as S_I/S_n , which was stated earlier to be a given in control systems, will simply be wrong. This makes proper planning impossible.

Feedback Loops – A feedback loop is imperative as it allows the planner to determine or measure the success of operations.¹⁵ Accurate feedback may also allow one to determine disturbances by comparing E_A and E_C (effects), or the environment, to determine D. The problem is that current processes do not provide adequate feedback loops. While much work has been done here to provide better video feeds, persistent surveillance, and other technological tools, these are limited tactical tools that provide a snapshot of the environment, not the true feedback loop required to provide accurate information for the assessment. This snapshot (or video feed) provides limited assessment of tactical events, but does not provide either the persistence or totality that is required to understand the operational environment. Despite the belief of technology advocates, the amount of information required to provide an adequate feedback loop would be both impossible to gather and to process.¹⁶ The fact that this feedback loop is required for accurate assessment of any open system demonstrates some of the fundamental problems with EBO.

Predictive Nature – Control systems are able to predict and correct their actions by knowledge of the initial state and through feedback, but also through understanding disturbances. In science, this can be done by understanding the properties one is dealing with and applying general rules. An open social system makes it nearly impossible to account for these disturbances and thus requires EBO planners to be predictive in nature.¹⁷ This means that planners must often overcome an incomplete picture of the state and poor feedback. Concomitantly, they must base their plans on predicted actions.¹⁸ While the social sciences may provide a template for typical behavior in this model, it fails to account for the all-too-common atypical behavior of individuals or societies. The problem is that without either S_I/S_n or E_C , accurate predictions of expected actions are even harder to achieve.

EBO: Value and Assumptions

While there are problems with EBO at the operation level of war, the EBO concept does add value. This value may be found in two broad categories that have been well examined by many professionals. The first of these is the greatly expanded considerations one takes into account when planning operations using EBO. While the challenges of knowing S_I have been discussed, by applying a more complete analysis of both the initial situation and the current situation, the military planner is attempting to break out of the silo of traditional planning. This fosters the second manner in which EBO may be of utility – consideration of the full spectrum of power. Attempting to consider the changes that come from the actions one takes, as well as the potential disturbances that could occur means that planners are more open to the manner in which traditional military force may not realize the desired effect. This in turn helps to foster greater acceptance of solutions outside of the traditional military playbook.

Despite the value that EBO may add to a planning process, several critical assumptions must be examined. The first three of these have already been introduced and will only be briefly recapped.

Known State – EBO is based heavily on understanding both the initial state and the state following any action taken. With an open system and limited ability to truly understand complex social situations, this assumption is flawed. This will result in an inability to accurately find causality between the effects and the actions taken.

Feedback – The advances in technology, both in terms of speed and capability, lead many to assume that an effective feedback loop exists or will exist in the near future. Once again, the open nature of this system as well as the limited scope of any system to capture feedback invalidates this assumption.

Prediction - The fact that S_I/S_N is impossible to fully capture means that the only manner of solving this problem is by accurately predicting disturbances that will affect the system. The ability of social systems to mutate and adapt in unforeseen manners to actions taken against them greatly lessens the chance of this occurring.¹⁹ While the disturbances may occasionally be correctly predicted and yield the desired effects, the problem is duplicating this success. Even more dangerous here is assuming that success in a certain environment (society) means that these lessons can be repeated outside of that place and point in time.²⁰ Not only is the result likely to be different in a different location, it is likely to be different at a different period of time.

Optimum Solution – While not overtly discussed, EBO gives rise to the search for an optimum solution.²¹ This is based on achieving the desired effect with minimal expenditure, meaning one must find the optimum solution to the problem – whether military or otherwise. An optimum solution is one that is targeted to achieving a desired effect. The problem with optimum solutions lies in their variance and what occurs when one is off target. An example is the rapid and well-executed U.S. drive through Iraq in OIF. Based on the given situation and known facts, this was the so-called optimum solution to the problem presented. The problem is that when these assumptions prove wrong, it is susceptible to a wide range of

possible outcomes. Robust solutions will be explored later as a possible alternative to this.

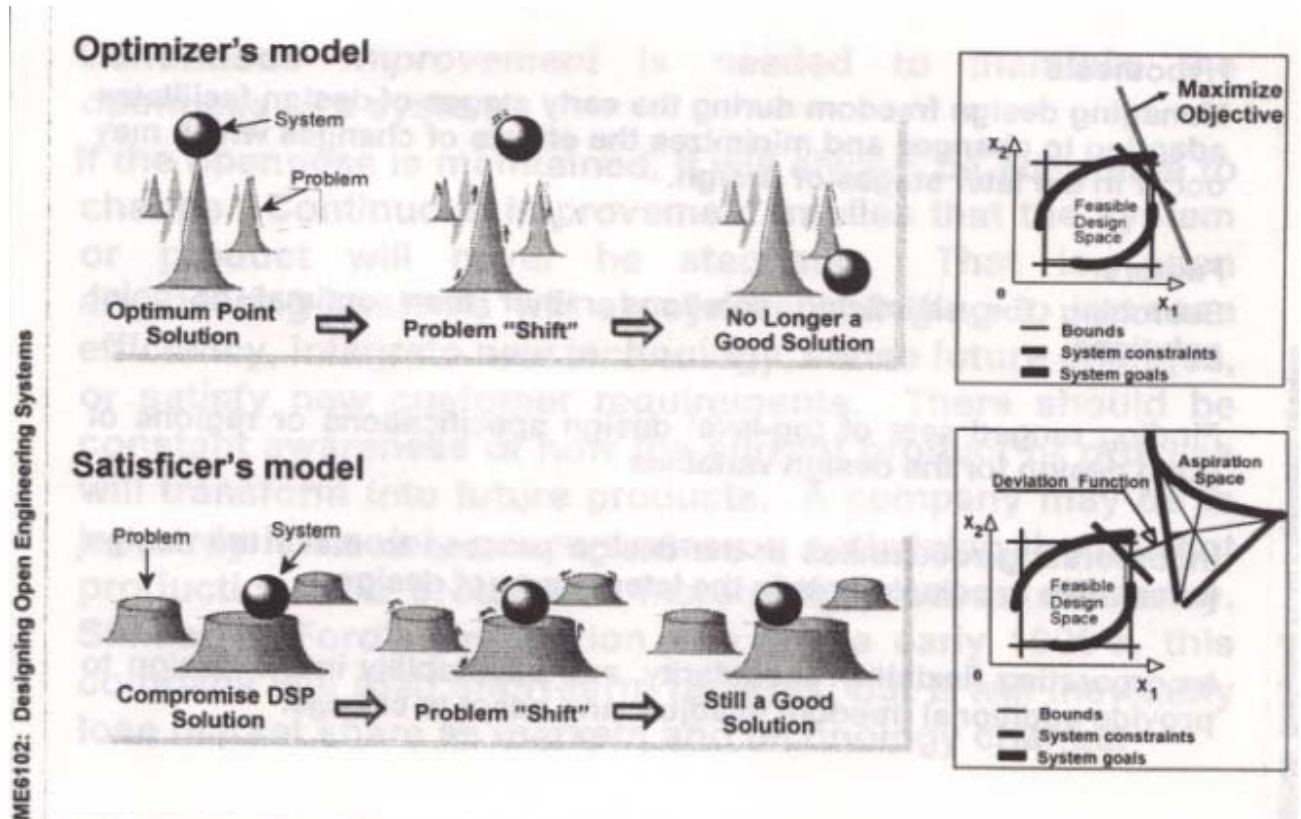


Figure 3: Optimum Solution versus Robust. Small disturbances can cause failure of optimum solutions while robust are accept slightly lower results in exchange for greater resistance to these disturbances. (Mistree, 2005)

Command and Control (C2) – EBO makes the assumption that C2 networks will exist to allow this type of information to flow both up and down the chain of command. This is an assumption beyond mere bandwidth, one that assumes U.S. planners will be able to receive and send information in a timely manner. This assumes that operational protection will ensure U.S. C2 networks remain viable in challenging situations such that even the primitive feedback loop that currently exist function.²² With the growing cyber threat, as well as the knowledge adversaries have of U.S. reliance on this type of information, this comforting assumption may prove untrue in future confrontations.

U.S. Technological Superiority – EBO is implicitly based on the belief that U.S. technology will remain superior. Like sea control, the U.S. may remain able to dominate aspects of the battlefield, but it is unlikely that the U.S. will continue to dominate all aspects of warfare. When facing an enemy who is able to act and react faster than the U.S. or who has the ability to disrupt U.S. actions, EBO will rapidly break down. One reason for this is the aforementioned reliance on two-way C2. The second is that when an enemy succeeds in disrupting any significant portion of an “optimized” attack or weapon system, the overall effect will be seriously lessened and the system-wide results unpredictable.

Living Systems

The problems with the assumptions embedded in EBO raises the question of whether the benefits of the EBO process are due to the process itself or merely that it injects better ways of conducting certain aspects of planning. If this is the case, is there a better model that can be explored that employs these improved planning tools while also overcoming some of the deficiencies covered to this point? The answer to this is yes and the construct that should be explored is that of the living system.

In *The Nature of Living Systems: An Exposition of the Basic Concept of General System Theory*, James Miller lists the characteristics of a living system:

- 1) Open Systems
- 2) Use inputs of foods or fuels to provide energy or repair self.
- 3) Have at least a minimum degree of complexity
- 4) Contain DNA
- 5) Mostly Contain protoplasm
- 6) Have a decider which causes systems and sub-systems to interact
- 7) Possess other subsystems or relationships with other living or non-living systems which carry out the process of any such subsystem they lack.
- 8) Subsystems are integrated to form actively self-regulating, developing, reproducing with purposes and goals.
- 9) Can only exist in a certain environment.

While some items do not directly apply to the military environment (DNA, protoplasm), these characteristics can describe both the environment the military plans in as well as the structure the military uses to control its interaction with this environment.

Open Systems – The operational environment has been discussed in this paper as one that is an open system subject to stimuli from multiple sources.

Complexity – The operational environment dealt with is one of great complexity with various factors that must be included. The inclusion of a civilian population in the planning process only increases the complexity of the problem.

Contain a decider – This is analogous to C2 systems and commanders who direct and synchronize forces as well as the interaction between these forces and outside elements.

Self-Regulating/Developing/Reproducing with purposes and goals – The military is analogous to all of these and moves towards definitive purposes and goals. It regulates itself, develops structures, and produces more troops while acting with a definitive purpose.

Can only exist in certain environments – Military forces can only exist in certain medium. Attempts are made to evolve such that these environmental constraints are overcome, but while the environmental constraints have been lessened they still exist. Just as a virus needs a host to survive or a polar bear is unable to survive in the desert, the airman cannot operate underwater or the soldier in the sky. Evolution might expand the habitat of the organism, but just as with a military, it is a gradual process.

With both the living system and military existing in open, complex, and constraining environments, a commonality of environments becomes evident. This commonality extends beyond the environment, however, with both entities being purposeful, learning systems that contain a C2 element. Due to the commonality between the military and the living system

and the environment in which it operates, it is important to also look at several facets of living systems, namely the areas of feedback and robustness, which may provide useful tools for overcoming some of the challenges identified earlier.

With the human exception, living systems lack the ability to try and predict changes to their system and thus utilize two forms of feedback to try and more quickly react to their environment. The first and more common of these is negative feedback which is what regulates functions and attempts to maintain x status by causing y response. Positive feedback is used to promote changes in systems as they copy successful behavior of other organisms (such as birds landing in a lake due to other birds being there).²³ Two important considerations must be taken into account with all feedback. First, the feedback is reactive to both internal and outside events; it is not predictive. Second, positive feedback can lead to problems of its own where “positive” actions cause unintended and destabilizing events such as immune system over-action or predator over-population. With living systems utilizing feedback in a purely reactive manner, the question is how do living systems overcome the effect of stimuli before they are able to react.

The answer to that question is the employment of robustness to allow them to continue functioning despite disturbing events.²⁴ Four aspects of robustness in living systems allow them to overcome these disturbances. First, they use control systems to ensure dynamic stability at certain points. Second, they increase tolerances to prevent component failure or environmental changes by redundancy, alternative functions, or alternative means to overcome disruption. Third, they utilize modularity to isolate disturbances from the rest of the system. Fourth, they utilize decoupling to isolate variations from system functions and interactions.²⁵ This robustness is an evolutionary process that helps living systems survive

and adapt when faced with external stimuli that change by either attacking the living system itself or changing the environment.²⁶

These aspects of living systems point to a path different from that taken by EBO. First, with the understanding that feedback is purely reactive and often incomplete, it means that systems must be able to survive disruptions to their environment. This means using a robust approach for designing C2 structures which fosters both synchronized top-down activity and locally synchronized bottom-up activity. The U.S. C2 network has only focused on the first with no expectation that operation protection through redundant paths or C2 structures would be needed due to network disruption or degradation. It also means designing systems and structures that are robust in terms of capability and also in response to enemy disruption (dynamic stability). As discussed earlier, this often means accepting a lower capability (less optimized) in exchange for a greater ability to withstand disturbances. With the increasing U.S. reliance on technology, it also means designing systems that are able to function within the networked framework as well as autonomously (decoupled) without any system degradation. Finally, living systems have shown that in nature numbers matter. This allows modularity and redundancy by replacing one item with another, as well as providing alternate means of accomplishing tasks. Unfortunately, concepts such as the Global JFMCC move in the opposite direction by utilizing optimally configured non-redundant networks instead of the robust architecture advocated here. This exposes U.S. systems to catastrophic system-wide failure when they are needed most.

The Operation Level of War: Living System vice Control System

The living system model presented several alternative strategies to pursue in order to better resist the dynamic disturbances found in the operational environment. It is also

beneficial to analyze the manner in which living systems deal with the three previously identified problems with EBO.

By their nature, living systems are open systems, meaning they cannot restrict the time or space they operate in. It also means that the living system is subject to disturbances that it cannot predict, requiring it to develop other tools to overcome this as addressed above. While living organism are subject to daily attacks by viruses, bacteria, as well as, the environment itself, by robustly designing defenses that are able to act both autonomously and under the direction of coordinating authority, they are able to overcome some of their inability to predict future events. This does not mean that living systems always win this battle simply that they have a methodology of combating these disturbances. As in all affairs, some disturbances are simply too large to overcome.

While EBO is based on assessment of S_I/S_N , living systems approach this problem by acknowledging and planning for a lack of information. The living system model recognizes and embraces the lack of complete, accurate, and timely information and strives to overcome this through robustness, redundancy, and locally synchronized responses. The living system recognizes that the assessment is prone to delay and reactive to the situation the organism already finds itself in. This is shown by the AIDS virus which first manifested itself in the 1970s or earlier, but was not even recognized, much less understood, until the early 1980s.²⁷ On the sub-system level, the body was fighting a virus well before it was cognitively identified, assessed, or combated. While AIDS does not speak to the ability of living systems to overcome all disturbances, it shows that the living system model better represents the dynamic environment and often unseen disturbances found in any social system. By building

on a model that recognizes this lack of information, planners are presented with a model that is better able to deal with the uncertainty of dynamic open systems.

Finally, while both control systems and living systems use feedback loops, the living system uses feedback loops that can function when they are degraded. This is important as in open systems even when disturbances can be anticipated, they cannot be anticipated with any high degree of accuracy. This is seen in the yearly flu vaccine where months in advance the most likely and deadly variations are built into the vaccine. This, however, is only a guess and these often do not match the strains seen or the veracity of the strains. In this, feedback is only seen after the fact and it is still incomplete. This demonstrates the problem with feedback in open systems as it is most accurate when assessed while looking back and even then it is often still not completely accurate. For as stated in *On War*,

“The deduction of effects from cause is often blocked by some insuperable extrinsic obstacle: the true causes may be quite unknown. Nowhere in life is this so common as war, where the facts are seldom fully known and the underlying motives even less so. They may be intentionally concealed by those in command, or, if they happen to be transitory and accidental, history may not record them at all.” (Clausewitz, *On War*, p156)

Additionally, as discussed earlier, problems exist when trying to apply this “look back” towards future events. In living systems, the ability to function whether or not feedback loops are working is made possible by facilitating bottom-up actions. This is important as EBO assumes U.S. information superiority while a living system model works both with direction from the top and without it.

The use of the living system as a model attempts to mitigate the assumptions that EBO makes. In this, the model that would be developed is less precise, but more applicable to all levels of war. In this model EBO still has its place, but it is at the sub-tactical level where it is used in the target-selection manner from which it was born. The use of a living

system model recognizes that war is not a technical system and a model based on this, namely control theory, does not adequately account for the disturbances found in war.

Applying the living system construct better prepares for threats of all levels. In EBO, these threats are often assumed to be of no factor, but that is a dangerous assumption. The living system model makes no assumption about peer competitors; it simply prepares for disturbances. By employing the living system model, systems are built with robustness in mind so they are able to respond to all types of threats instead of simply the anticipated threat.²⁸ Too often EBO assumes that the optimum U.S. solution will be viable in the future. With an enemy aware of U.S. actions, the environment the U.S. is in is even more dangerous than the viral examples presented earlier. In this environment the enemy is sentient and while viruses react and adapt to overcome the bodies' defenses, the enemy here is able to recognize trends in U.S. behavior before they even appear. This allows the threat to not only react to U.S. defenses, but also to pre-empt these defenses. Finally, the living system model advocates that the U.S. develop a C2 structure that functions both top-down and bottom-up. As part of this, the development of elements that work in the traditional directed sense, but which are also able to synchronously actions at lower levels when higher level direction is not present, is crucial.

Conclusions

While EBO presents useful ideas that are important in terms of expanding the considerations that planners take in applying the operational art, the assumptions implicit in EBO negate its long-term possibilities. These assumptions of understanding of the system state; the ability to predict the manner in which the system will react to stimuli, and that feedback loops are present and viable open the construct up to catastrophic collapse at the hands of an enemy that is able to disrupt or manipulate certain aspects of the EBO model.

While only proposed in rudimentary details here, the living system model attempts to overcome these assumptions by designing a robust, survivable system. A great deal of experimentation and scholarly work would need to be done to develop this concept fully, but the principles can be applied today to the structures and platforms being built by the U.S. Just as organisms have evolved over millennia while still remaining relevant, this model tries to do the same by building capabilities that do not rely on single point structures such as C2 networks, GPS, or other elements that may not be available in a future environment. For while EBO may appear to provide an optimized solution today, the permissive environment the U.S. operates may not occur tomorrow and the cost of missing the target in an optimized systems can be disastrous for both the fielded forces and the nation itself.

END NOTES

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- ¹ Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1984), 108.
- ² Darwin, Charles, *On the Origins of Species: By Means of Natural Selection or The Preservation of Favored races in the Struggle for Life*, (New York: Cosimo Inc., 2007 (originally published 1859), 51.
- ³ Dawen, Choy, "Effect-Based Operations: Obstacles and Opportunities," *Pointer* 30, no. 2 (Nov. 4, 2004): <http://www.mindef.gov.sg/imindef/publications/pointer/journals/2004/v30n2/features/feature3.html> (accessed 2 APR 2008)
- ⁴ Meilinger, Phillip S., "A History of Effects-Based Air Operations," *The Journal of Military History* 71, no. 1 (January 2007): 165.
- ⁵ Ibid., 164.
- ⁶ Meilinger, Phillip S., "The Origins of Effects-Based Operations," *Joint Force Quarterly* 35, (Autumn 2004): 117.
- ⁷ Davis, Paul K., *Effects-Based Operations: A Grand Challenge for the Analytical Community*, (Santa Monica, CA: RAND, 2001), 23.
- ⁸ Dawen, Choy, "Effect-Based Operations: Obstacles and Opportunities," *Pointer* 30, no. 2 (Nov. 4, 2004): <http://www.mindef.gov.sg/imindef/publications/pointer/journals/2004/v30n2/features/feature3.html> (accessed 2 APR 2008)
- ⁹ A control system consists of subsystems or process assembled for the purpose of controlling the output of processes. As defined, a control system provides an output for a given input or stimulus. Nise, Norman, *Control System Engineering* (2nd Edition), (Menlo Park, CA: Addison-Wesley Publishing Company, 1995), 2-3.
- ¹⁰ This list includes *Understanding Command and Control* (Alberts and Hayes, 2006), *Complexity, Networking, & Effects-Based Approaches to Operations* (Smith, 2006), *Understanding Information Age Warfare* (Alberts, Garstka, Hayes, and Signori, 2001), *Complexity Theory and Network Centric Warfare* (Moffat, 2003), and *Effects Based Operations* (Smith, 2002).
- ¹¹ Farrell, Philip, *Control Theory Perspective of Effects-Based Thinking and Operations: Modelling "Operations" as a Feedback Control System*, Defence R&D Canada Technical Report 2007-168, (Ottawa: Defence Research and Development Canada, 2007), 4-5.
- ¹² Closed-loop control systems measure response, comparing it with the input, and determining the difference between the values. If a difference exists, the control system adds a correction input to drive the two values towards equality. Likewise, if no difference exists, the system adds no additional input into the system. Nise, Norman, *Control System Engineering* (2nd Edition), (Menlo Park, CA: Addison-Wesley Publishing Company, 1995), 12-13.
- ¹³ Mundy, Timothy, *The Applicability of Effects-Based Approach to Planning at the Different Levels of War*, (Norfolk, VA: National Defense University, 2007): 1.
- ¹⁴ Murray, Williamson, *Transformational Concepts for National Security in the 21st Century*, (Carlisle, PA: Army War College, 2002), 106
- ¹⁵ Smith, Edward, *Complexity, Networking, and Effects-Based Approach to Operations*, (Washington D.C.: DoD Command and Control Research Program, 2006): 97-106.
- ¹⁶ Berg, Paul, "Slow-Airpower Assessment: A Cause for Concern?" *Air & Space Power Journal* XVIII, no. 1 (Fall 2004): 78.
- ¹⁷ Ibid., 81.
- ¹⁸ Lazarus, David, "Effects-Based Operations and Counterterrorism," *Air & Space Power Journal* XIX, no 3. (Fall 2005): 23.
- ¹⁹ Vego, Milan, "Effects-Based Operations: A Critique," *Joint Force Quarterly* 41, (Summer 2006): 52-53.
- ²⁰ Smith, Edward, *Complexity, Networking, and Effects-Based Approach to Operations*, (Washington D.C.: DoD Command and Control Research Program, 2006): 73.
- ²¹ Vego, Milan, "Effects-Based Operations: A Critique," *Joint Force Quarterly* 41, (Summer 2006): 55.
- ²² Mundy, Timothy, *The Applicability of Effects-Based Approach to Planning at the Different Levels of War*, (Norfolk, VA: National Defense University, 2007): 35.

²³ Camazine, Scott et al., *Self-Organization in Biological Systems*, (Princeton, New Jersey: Princeton University Press, 2001), 15-20.

²⁴ Choi, Sangdun, *Introduction to Systems Biology*, (Totowa, New Jersey: Humana Press, 2007), 5.

²⁵ Ibid., 5-6.

²⁶ Wagner, Andreas, *Robustness and Evolvability in Living Systems*, (Princeton, N.J.: Princeton University Press, 2005), 310-311.

²⁷ The Henry J. Kaiser Family Foundation, "The Global HIV/AIDS Timeline."
<http://www.kff.org/hiv/aids/timeline/hivtimeline.cfm> (accessed 16 March 2008).

²⁸ Wagner, Andreas, *Robustness and Evolvability in Living Systems*, (Princeton, N.J.: Princeton University Press, 2005), 312-315.

SELECTED BIBLIOGRAPHY

Alberts, David, John J. Garstka, Richard E. Hayes, and David A. Signori. *Understanding Information Age Warfare*. Washington D.C.: DoD Command and Control Research Program, 2001.

Alberts, David, and Richard E. Hayes. *Understanding Command and Control*. Washington D.C.: DoD Command and Control Research Program, 2006.

Becker, Stephan. "Good news for Marburg virus workers." *The Lancet* 367, no 9520 (Apr 29-May 5, 2006): 1373-1374.

Berg, Paul. "Slow Airpower Assessment: A Cause for Concern?" *Air & Space Power Journal* XVIII, No. 3 (Fall 2004): 75-83.

Camazine, Scott, Jean-Louis Deneubourg, Nigel R. Franks, James Sneyd, Guy Theraulaz, and Eric Bonabeau. *Self-Organization in Biological Systems*. Princeton, NJ: Princeton University Press, 2001

Center for Disease Control, "Seasonal Flu." <http://www.cdc.gov/flu> (accessed 16 March 2008).

Choi, Sangdun. *Introduction to Systems Biology*. Totawa, NJ: Humana Press, 2007.

Clausewitz, Carl von. *On War*. Edited and translated by Michael Howard and Peter Paret. Princeton, NJ: Princeton University Press, 1984.

Crowder, Gary. "Effects-Based Operations: The Impact of Precision Strike Weapons on Air Warfare Doctrine." *Military Technology* 27, Part 6 (2003): 16-25.

Darwin, Charles. *On Origins of Species*. New York: Cosimo, 2007.

Dawen, Choi. "Effects-Based Operations: Obstacles and Opportunities." *Pointer* 30, no. 2 (Nov. 4, 2004). (<http://www.mindef.gov.sg/imindef/publications/pointer/journals/2004/v30n2/features/feature3.html>) (accessed 02 APR 2008)

Davis, Paul. *Effects-Based Operations: A Grand Challenge for the Analytical Community*. Santa Monica, CA: RAND, 2001.

Elder, Robert. "Effects-Based Operations: A Command Philosophy." *Air & Space Power Journal* XXI, No. 1 (Spring 2007): 10-17.

Farrell, Alison. "Defeating T-cell fatigue in HIV." *Nature Medicine* 12, no. 10 (October 2006): 1124-1125.

Farrell, Philip. *Control Theory Perspective of Effects-Based Thinking and Operations: Modelling "Operations" as a Feedback Control System*. Defence R&D Canada Technical Report 2007-168. Ottawa: Defence Research and Development Canada, 2007.

Goldstein, Jeffrey. "Social Psychology and Nonlinear Dynamical Systems Theory." *Psychological Inquiry* 8 (1997): 125-129.

Herndon, Robert et al. "Effects-Based Operations in Afghanistan: The CJTF-180 Method of Orchestrating Effects to Achieve Objectives." *Field Artillery*, (Jan-Feb 2004): 26-30.

Hunerwadel, J. "Israel's Failure: Why?" *Air & Space Power Journal* XXI, No. 4 (Winter 2007): 22-27.

Jenson, Hendrik. *Self-Organized Criticality: Emergent Complex Behavior in Physical and Biological Systems*. Cambridge: Cambridge University Press, 1998.

Jobbagy, Zoltan. "Adaptive Command and Control: An Organic Model." Powerpoint. December 2007.

Johnson, Daniel. *Enabling Intelligence, Surveillance, and Reconnaissance Effects for Effects-Based Operations Condition*. Maxwell, AL: Air University Press, 2005.

Joint Warfighting Center. "An Effects-Based Approach: Refining How We Think about Joint Operations." Issue 44 (1st Quarter 2007): 1-6.

Kaneko, Kunihiro. *Life: An Introduction to Complex Systems Biology*. Netherlands: Springer, 2006.

Kober, Avi. "The Israel Defense Forces in the Second Lebanon War: Why the Poor Performance?" *Journal of Strategic Studies* 31, Issue 1 (February 2008): 3-40.

Kumashiro, David. *Microsoft, Al-Jazeera, and the Predator: The Challenges of Effects-Based Operations in the Global War on Terrorism*. Maxwell, AL: Air University Press, 2005.

Lazarus, David. "Effects-Based Operations and Counterterrorism." *Air & Space Power Journal* XIX, No. 3 (Fall 2005): 22-28.

Mann, Edward, Gary Endersby, and Thomas Searle. *Thinking Effects: Effects-Based Methodology for Joint Operations*. Maxwell, AL: Air University Press, 2002.

Meilinger, Phillip. "A History of Effects-Based Air Operations." *The Journal of Military History* 71 (January 2007): 139-168.

_____. "The Origins of Effects-Based Air Operations." *Joint Force Quarterly*, no. 35 (Autumn 2004): 116-122.

Mistree, Farrokh. "ME6102 Designing Open Engineering Systems: Robust Design." Powerpoint. Spring 2005.

Department of Defense's Office of Force Transformation Report. *Military Transformation: A Strategic Approach*. Washington D.C: Office of the Secretary of Defense, 2003.

Miller, James. "*The Nature of Living Systems: An Exposition of the Basic Concepts in General Systems Theory*." Washington D.C.: Office of Education, 1970 (updated 1978).

Moffat, James. *Complexity Theory and Network Centric Warfare*. Washington D.C.: DoD Command and Control Research Program, 2003.

Mundy, Timothy. *The Applicability of the Effects-Based Approach for Planning at the Different Levels of War*. Norfolk, VA: National Defense University, 2007.

Murray, Williamson. *Transformational Concepts for National Security in the 21st Century*. Carlisle, PA: Army War College, 2002.

National Institute of Health, "In Their Own Words: AIDS Timeline."
<http://aidshistory.nih.gov/timeline/index.html> (accessed 16 March 2008).

National Science Foundation, "Biology: Overview."
http://www.nsf.gov/news/overviews/biology/bio_q01.jsp (accessed 16 March 2008).

Nise, Norman S. *Control Systems Engineering*. 2nd ed. Menlo Park, CA: Addison-Wesley Publishing Company, 1995.

Smith, Edward A. *Complexity, Networking, and Effects-Based Approaches to Operations*. Washington D.C.: DoD Command and Control Research Program, 2006.

_____. *Effects Based Operations: Applying Network Centric Warfare to Peace, Crisis, and War*. Washington D.C.: DoD Command and Control Research Program, 2002.

The Henry J. Kaiser Family Foundation, "The Global HIV/AIDS Timeline."
<http://www.kff.org/hivaids/timeline/hivtimeline.cfm> (accessed 16 March 2008).

Tira, Ron. "Breaking the Amoeba's Bones. *Strategic Assessment* 9, No 3 (November 2006): 13-15. (English translation accessed via http://www.tau.ac.il/jcss/sa/volume9_3.html on 16 March 2008)

Vego, Milan. "Effects-Based Operations: A Critique." *Joint Force Quarterly* 41 (2nd Quarter 2006): 51-57.

Wagner, Andreas. *Robustness and Evolvability in Living Systems*. Princeton, N.J.: Princeton University Press, 2005.

Wielhouwer, Peter. "Towards Information Superiority." *Air & Space Power Journal* XIX, No. 3 (Fall 2005): 85-96.

Yang, Xiao-Song and Lei Wang. "Emergent Periodic Behavior in Coupled Chaotic Systems." *Advances in Complex Systems* 9, No 3 (2006): 249-261.